The physics of sports: the math and science behind a champion

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This curriculum unit is recommended for:
7th Grade Science

Keywords: Physics, forces and motion, energy, speed, velocity, acceleration, Newton's Laws, inertia, work, power, momentum, collision

Teaching Standards: See Appendix for teaching standards addressed in this unit.

Synopsis: This unit seeks to engage Middle School students in the physics concepts surrounding forces, motion, and energy by relating these concepts to sports. This unit was specifically designed for 7th grade science students, working in tandem with the 7th grade math curriculum. Students will not only understand physics concepts like speed, velocity, acceleration, and momentum, but they will also learn how to use math to identify relationships between variables and chart their data using graphs and charts. By using real-world situations and applying math and science to sports, students become more engaged in the content they are learning, and they no longer ask that dreaded question, "Why do we need to learn this?" In this unit, students are expected to think on a higher level with a variety of cooperative learning activities, including a culminating unit project where students have the opportunity to select their favorite athlete and compare him or her to winning Olympic athletes using a variety of physics-based statistical measures. Technology, literacy, and collaboration are two twenty-first century skills that are deeply embedded in this unit. Students will engage in internet-based research, learn to work closely and cooperatively with their peers, and even engage in argumentative writing.

I plan to teach this unit during the coming year to 130 students in 7th grade science.

The physics of sports: the math and science behind a champion

Stephanie Coggins

Introduction

A common theme that runs through the population of the students I teach is their love for sports. The majority of my students either plays a sport or is a fan of a sport. These sports range from football, golf, baseball/softball, basketball, gymnastics/tumbling, track, cheerleading, volleyball, lacrosse, NASCAR, and even RC car racing. With this in mind, I have designed a unit on forces, motion, and energy that keeps the inevitable question, “Why do we have to learn this?” out of the mouths and minds of my 7th Grade Science students.

Rationale

This unit seeks to engage Middle School students in learning about forces, motion, and energy through a variety of sports. My goal is to help students learn how to do more than just memorize formulas and plug numbers into them, spitting out an answer to which they have no meaningful connection. It is my vision that students will realize the trends in the data they are collecting and analyzing by making connections from the real world with their data. The strategies that my students will take away from this unit will allow them to carry a skill-set with them that will benefit them in their everyday lives, thus never having to ask the question, “Why do we have to learn this?”

This unit is specifically designed for 7th Grade Science students and crosses curriculum perfectly with 7th Grade Math, particularly in dealing with algebraic expressions, creating, analyzing, and interpreting data, and comprehension of word problems. Due to the fact that 7th Grade Science is not considered a tested area (unlike Language Arts or Math), 7th Grade Science classes are often heterogeneously created with no regard to Honors or Standard grouping.

This unit bridges the gap between my Honors and Standard students, and creates what educators call the “motivation trap”, luring students into engaging in the lessons by using an activity they in which they are interested, in this case, sports.[1] Advanced learners are susceptible to producing “success without effort” and can fall into the trap of thinking grades can become more important than ideas, so when faced with more rigorous assignments, they may have failed to develop appropriate study and coping skills.[2] Conversely, struggling learners may have a hard time understanding the deeper content and can have a difficult time when assignments aren’t chunked into manageable sections.[3] This unit is designed to engage all levels of students through a variety of engaging video clips, collaborative group activities, independent assignments, and a culminating unit project, while providing rigor for the advanced learners and responding to the needs of the struggling learners.

Student Population

I teach 7th Grade Science at Bailey Middle School in Cornelius, North Carolina. Bailey Middle School is a part of the Charlotte-Mecklenburg School District, which is currently made up of 176 schools. While many of the district's schools are in an urban setting, Bailey is quite different. We are located in an area that accommodates a rather affluent population. Bailey has 1575 students, and a free and reduced lunch population of 24.1%, which is below the CMS average. The student makeup is as follows: 76.5% Caucasian, 12.2% African-American, 7.3% Hispanic, 2% Asian, and 1.9% Other.

Although 7th Grade Science is not grouped according to Honors or Standard like Math, I teach on a team where two of my four classes are Standard for Math, one is an Honors class, and this year for the first time we have one class that is a 7th Grade Algebra class (considered a step above Honors). Of the two Standard Math classes, one is an inclusion class that accommodates students with a variety of IEPs and 504s. All of this means that not only are my four Science classes extremely heterogeneous, but they also span the entire spectrum in terms of ability level.

Last year, Bailey Middle School was among schools selected to participate in the start of the Bring Your Own Technology or BYOT program, where our students are permitted to bring in their own electronic devices to use as educational resources in the classroom via school Wi-Fi. For students who do not have access to their own technology, I also have 5 student computers in my classroom, and my school currently has iPad and Google Chrome netbook carts that teachers may check out to use in our classrooms.

Bailey was recognized in 2011-2012 as an Honor School of Excellence, which means that at least 90% of students' scores are at or above achievement Level III and the school makes or exceeds its expected growth goal. In addition, Bailey also met all of its Annual Measurable Objectives targets.

The majority of our students are involved in some kind of extra-curricular activity, either through the school or otherwise. Students are involved in a variety of sports (both through the school and in recreational leagues), as well as Orchestra, Performance Band, Honors Chorus or Dance, and Theater. Each teacher advises a club that meets once a week during a time period we call REC. We have a very high level of parent involvement. As a team with our faculty and parents we have created a school climate that is both rigorous and nurturing.

Instructional Content

Vocabulary and Concepts

Speed

Speed is defined as the distance an object moves in a given amount of time. It is represented by the algebraic equation ***Speed = distance/time, or S = d/t***. If two objects travel the same distance, the object that took a shorter amount of time will have the greater speed. An object with greater speed will travel a longer distance in the same amount of time than an object with a lower speed will. The standard unit for speed is m/s (meters per second). We also use mph (miles per hour) to describe speed.

Velocity

Velocity is defined as speed in a specific direction. If two objects have the same speed but are traveling in different directions, they have different velocities.

Distance-Time Graphs

Distance-time graphs lot the distance against the time of an object to show its motion. Time runs along the horizontal axis and distance runs along the vertical axis. As an object moves, the distance it travels increases with time, which is illustrated as a climbing or rising line on the graph. A flat (or horizontal) line shows an interval of time where speed is 0 m/s, or the object is not moving. The faster the object is moving, the steeper the line will be. The slope of the line is equivalent to the speed of the object.

Acceleration

Acceleration is the rate at which velocity changes with time, or a measure of how quickly velocity is changing. Acceleration doesn't just mean speeding up. It can also refer to slowing down, or even changing direction without changing speed. The algebraic formula for acceleration is ***Acceleration = (final velocity – initial velocity)/time, or*** $A = (v_f - v_i)/t$. Since velocity is expressed in m/s and time is expressed in s, acceleration is expressed in m/s^2.

Force

A force is a push or pull. Anytime you change the motion of an object, you use force. Types of forces include contact force (when one object pushes or pulls another by touching it), gravity (see below), and friction (see below). *See Newton's Second Law or the algebraic expression for force.

Friction

Friction is the force that resists motion between two surfaces in contact with one another. Friction between two surfaces depends on three things: the materials that make them up different combinations create different amounts of friction), motion (it's easier to apply force to an object once it's in motion than once it's stopped), and pressure (the harder two surfaces are pushed together, the more difficult it is for them to slide over one another). Friction between two surfaces produces heat, because molecules are speeding up. The faster the molecules move, the higher the temperature. Air resistance is the friction due to air. Air resistance depends on surface area and the speed of an object. Increased surface area = increased air resistance, and increased speed = increased air resistance.

Gravity

Gravity is the force of attraction between two objects. The strength of the gravitational force between two objects depends on mass and distance. The more mass an object has, the greater the gravity that is exerted on the other object. As distance increases, gravity decreases. The acceleration of an object towards the Earth due to the Earth's gravity is called a "g", and is equal to 9.8 m/s^2. Using the algebraic expression for force, $F = ma$, "g" (or 9.8 m/s^2) would be substituted in for acceleration. Two objects with different masses fall at the same rate because the object with greater mass has more gravity exerted on it, but greater mass also means more inertia, so the greater force doesn't produce a larger acceleration. Students should be able to distinguish between mass and weight. Mass is how much matter something contains, while weight is the force of gravity on an object, which can change based on location (like Earth vs. the moon, for example).

Balanced Forces

Balanced forces have the same effect as no force at all, meaning that the motion of the object does not change. Balanced forces have a net force of zero, and cause no motion. When forces are balanced on an object, that object is in a state of equilibrium.

Unbalanced Forces

Unbalanced forces cause change to the motion of an object.

Newton's First Law

Newton's First Law (sometimes called the Law of Inertia) states that an object at rest stays at rest, and an object in motion stays in motion at the same velocity, unless acted upon by an unbalanced force. Simply put, applying force changes the motion of an object.

Inertia

Inertia is defined as the resistance of an object to a change in the speed or direction of its motion. The more mass something has, the harder it is to change its motion. For example, it's easier to stop an empty wagon than a wagon full of sand. Inertia is the reason people in cars need to wear seat belts.

Newton's Second Law

Newton's Second Law states that acceleration of an object increases with increased force and decreases with increased mass. The direction in which an object accelerates is the same as the direction of the force. This can be translated into the algebraic expression, ***Force = mass x acceleration, or F = ma.*** Force is measured in units of mass (kg) x units of acceleration (m/s^2). The standard unit of force is the newton (N), and a newton is the amount of force it takes to accelerate 1 kg of mass 1 m/s^2.

Centripetal Force

Centripetal force is any force that keeps an object moving in a circle. Without centripetal force, an object would go flying off into a straight line. Greater acceleration requires greater centripetal force, as does an object with more mass.

Newton's Third Law

Newton's Third Law states that for every action, there is an equal and opposite reaction. Forces always act in pairs, so every time one object exerts a force on another object, that second object exerts a force that is equal in size and opposite in direction back on the first object.

Momentum

Momentum is defined as a measure of mass in motion. Momentum is the product of an object's mass and its velocity, or ***Momentum = mass x velocity (p = mv)***. Momentum is similar to inertia, in that it depends on an object's mass. But unlike inertia, momentum also takes an object's velocity into account. Remembering that the mass of an object is measured in kg and the velocity of an object is measured in m/s, the unit of measure for momentum is kg x m/s. The direction of an object's momentum is the same as the direction of its velocity.

Collision

Collision is when two objects in close contact exchange energy and momentum. If two objects have different masses, the one with the less mass has a greater change in velocity (or is more affected). The combined momentum of two objects after a collision is the same as the combined momentum of those two objects before the collision. This is called conservation of momentum.

Pressure

Pressure is measured by how much force is acting on a certain area, or how concentrated a force is. You can increase pressure by increasing force. The algebraic expression for pressure is ***Pressure = Force/Area, or P = F/A***. Pressure is measured in Pascals (Pa). Think of a thumbtack. You are more successful pushing the thumbtack's small pin into a wall than putting your thumb itself through it.

Work

Work is defined as the use of force to move an object a certain distance. You only do work when you exert a force on an object AND move it. Work is calculated by using the algebraic expression, ***Work = force x distance, or W = fd***. Work is measured in joules (J).

Energy

Energy is the ability of a person or object to do work or cause change. When you do work on an object, some of your energy is transferred to that object. This is called transfer of energy and is measured in joules (J).

Kinetic Energy

Kinetic energy is energy of motion. Any moving object has some kinetic energy. The faster an object moves, the more kinetic energy it has. The algebraic expression for kinetic energy is ***Kinetic Energy = (mass x velocity^2)/2, or KE = ½ mv^2.*** This means that increasing the velocity of an object has a greater effect on the object's kinetic energy than increasing the mass.

Potential Energy

Potential energy is stored energy waiting to be converted into kinetic energy. You can give an object potential energy by changing its shape, like with a spring.

Power

Power is defined as the rate at which you do work, or how much work is done in a given amount of time. The algebraic expression for power is ***Power = Work/time, or P = W/t.*** The unit of measure for power is the Watt (W).

Teaching Strategies

The initial content of this unit is delivered through the use of a variety of strategies as to engage all types of learners in my classroom. Technology is a strategic component that is heavily threaded throughout the entire unit, as I am fortunate enough to have a Promethean Board and to teach at a BYOT school as discussed earlier. Towards the end of the unit, the culminating activity will require use of student computers/tablets on a daily basis for almost a week. If this unit would be taught at a school that does not have a BYT program, a computer lab would need to be utilized.

Guided notes and graphic organizers will be used via interactive student notebooks. Guided notes are used to deliver content through interactive presentations. Students are given guided notes with blanks so they fill in key words without having to spend the entire class writing while unable to truly focus on content. Supplemental graphic organizers are utilized to further comprehend key terms, concepts, and formulas. Students are encouraged to use examples from their own experiences and illustrate with drawings, pictures, and diagrams. In addition to this, there are teacher demonstrations and interactive student activities integrated into the lesson, allowing students to make connections with the content. Strategies like graphic organizers and guided notes are important because they allow students to improve their reading in four ways: decoding, fluency, vocabulary, and comprehension.

Inquiry is a critical component to any science classroom, and this lesson is no exception. Inquiry is a strategy that we use to not only keep students actively engaged in the lesson, but also to help them engage in problem-solving and higher-order thinking. These are real-world skills students will use throughout their lives.[4]

Video clips from sites like ESPN Sport Science and Science 360 are used as both an introduction to new concepts and a way to dive deeper into the content. Throughout engaging video clips, students are probed with discussion questions that they answer with their lab partners, groups, or within the entire class setting.

A large part of this unit uses ESPN Sport Science and Science 360 as an introduction to new concepts as a way to hook my students. ESPN Sport Science offers a variety of video clips including any sport you can think of, even archery or gymnastics. For example, the clip, “Boost”, shows clips of Shaun White at the X-Games and introduces students to concepts like speed and acceleration. The clip, “G-Force” talks about G force and its impact on NASCAR drivers. These video clips are a great way to get students engaged in what they may consider dry or boring material. Grabbing their attention from the beginning and hooking them with something exciting will tend to keep them engaged longer throughout the lesson.

For the formulas, a strategy called KQS is used. This strategy allows the students to break down word problems into chunks that decode foreign numbers and words.

- K: What do I know? The students will circle parts of the word problem that correspond with a variable and label it accordingly.
- Q: What is the question? Students will identify what the word problem is asking. They underline this component.
- S: Solve. Students will write out the formula for the question and then plug in variables.

Sample problem: David Beckham kicked a soccer ball going 10 meters per second for 6 seconds. How many meters did the ball travel?

- K: What do I know? Speed = 10 m/s; time = 6 s
- Q: What is the question? How many meters did the ball travel? So the question is asking for distance.
- S: Solve! Speed = distance/time. 10 m/s = x/6 s. x = 60 m.
  So the answer is: The ball traveled 60 meters.

It is important to adamantly stress to students the importance of showing their work through these steps, and explain how computation is not the same as "math" in this situation. In a very short amount of time, students will go from decoding the word problems to truly understanding what the questions are asking and how to answer them. This also translates to the math classroom, and when paired with the same strategy being taught by the math teacher the process is scaffolded in an educationally meaningful way.

Classroom Activities

Activity #1: Speed Racer

This activity serves as bit of an introduction to the unit. It is important to note that in this unit students are expected not only to solve word problems, but also to chart their data in charts and graphs and communicate their findings by writing.

Students will work in groups of 4 to complete this activity. Each group of four will be given a remote-controlled car, a calculator, a stopwatch, a lab worksheet (see Appendix A), and a section of the floor that is taped off with measurements marked from a meter stick, complete with start and finish lines. Each student will be assigned a role: timekeeper, driver, data recorder, and start line coach.

Students will run time trials with their remote-controlled car. They will start by recording their times it takes them to cross the finish line. (The drag strip is 20 meters long). Students will run three trials with their car from the start line to the 10-meter line, recording their time with each trial. Once three trials have been run, students will run three more time trials to the 15-meter line, recording their time with each trial. After these three trials have been run, students will run three more time trials to the 20-meter line, recording their time with each trial.

Students should have 3 sets of data with three trials each, and then students should find the average of the three trials. Once students have collected all of their data, they will calculate their car's speed for each trial. Once this is completed, students will create a line graph on their lab worksheetplotting these points and illustrating the relationship between distance, time, and speed. During group discussion, students will discuss these relationships as well as any observations they made during the time trials. Did the cars seem to maintain a consistent speed throughout the trial? Is that a factor? Why does that matter? (This will serve not only as a lesson for speed, but an introduction to acceleration.)

Once the data has been charted, the data recorder from each group will chart their fastest time to the 20-meter finish line on a large piece of chart paper on the board in the front of the classroom. Students will calculate speed as a class for each group's fastest time and then determine whose group had the fastest car. Why was this group's car the fastest? What factors could have been involved?

This activity gives students a chance to not only practice graphing, but to also truly understand the relationship between distance, time, and speed. Additionally, this is an opportunity to discuss the concept of error within scientific experimentation and data collection, and why we run three time trials. (This is where we can discuss the concept of average speed. Average, or mean, is a central tendency that is covered in the first few weeks of 7th grade math.) This activity will appeal to kinesthetic learners, and appeals to the competitive nature of most middle school students. Students will be anxious to chart their data and find out who was the fastest driver, not only in their class, but overall!

Activity #2: Having a Ball!

Research shows that when students work kinesthetically with manipulative materials, it leads to a more positive attitude towards science. Further, using manipulative materials and laboratory equipment "significantly increases the speed at which students master concepts and assists students in developing problem-solving skills."[5]

For a change of scenery, this activity will take the class outside for the day to complete this lab activity. Students will use five balls: a basketball, a football, a soccer ball, a golf ball, and a baseball, and will have the opportunity to use each ball as it is intended. A series of questions will be asked before, during, and after the students play with them:

- What is the purpose of the basketball? How does it get used? Can you kick it? Throw it? Dribble it? What is the goal of basketball?
- What is the purpose of the football? How does it get used? Can you kick it? Throw it? Dribble it? What is the goal of basketball?
- What is the purpose of a soccer ball? How does it get used? Can you kick it? Throw it? Dribble it? What is the goal of soccer?
- What is the purpose of a golf ball? How does it get used? Can you kick it? Throw it? Dribble it? What is the goal of golf?
- What is the purpose of the baseball? How does it get used? Can you kick it? Throw it? Dribble it? What is the goal of baseball?

Following the questioning and student use of the balls the correct way, the students will be asked to use the balls in ways they were not intended. For example, dribble the baseball. Try to bounce the football off your head and get it into the soccer goal. Hit the soccer ball with a bat.

- Why didn't those things work?
- What does that have to do with the shapes and construction of the ball?
- And what in the world does that have to do with physics?

Students will be broken into groups of four and will have one of four short reading passages or videos explaining the physics behind the design of each ball, and its evolution over the life of the sport. Students will also be responsible for researching one other short article or video on their own that adds additional information to their selected topic.

- Baseball: Students will read a short one-paragraph passage and watch a 3 minute video on the website: http://curiosity.discovery.com/question/how-many-stitches-on-baseball
- Soccer: Students will read the passages on the website: http://www.soccerballworld.com/History.htm
- Football: Students will watch the 4 minute video "Science of NFL Football: Geometric Shapes- Spheres, Ellipses & Prolate Spheroids" from the website: http://www.nbclearn.com/nfl
- Golf: Students will read the article: http://www.scientificamerican.com/article.cfm?id=how-do-dimples-in-golf-ba

Once students have read these passages and discussed it in their groups, they will complete a graphic organizer (see Appendix B) highlighting the most important physics-related aspects of their ball. Using a basic jigsaw technique, students will shift into predetermined groups of four where they will be "experts" on their particular ball.

Students will then teach the other members of their group about their ball and the other students will be responsible for filling in the rest of their graphic organizers.

The jigsaw technique is a valuable tool for three reasons: it allows students to work collaboratively with one another, it teaches students how to pull truthful information from the text, and it provides the opportunity for students to separate tasks up into sections that they can manage.[6]

Upon completion of this lesson, students will decide on one type of ball they would like to write about. They will construct a one-page persuasive essay defending why they feel their ball's physical design is most important to their sport. They should be able to cite information from their jigsaw graphic organizer and be able to justify their reasoning, as well as use content-specific vocabulary.

This activity gives students confidence as they become "experts" with a specific ball. It also provides the students the opportunity to become the teacher, working with their peers to ensure understanding. As writing has become such an important part of the Common Core, this activity also lends itself to persuasive writing and citing specific textual evidence, while further developing the student's communication skills.

Activity #3:Scavenger Hunt: Formula for Success

At this point in the unit, it is important to note that students should have a deep understanding of the formulas and how each unit of measure relates directly to its function. For example, students must understand that speed is measured typically in meters per second (m/s) or miles per hour (mph). On a more basic level, students should understand the "/" or "p" represents the word "per", and that represents the mathematical operation of division. Students should be able to understand that speed relates to distance and time. It is not enough for students to be able to memorize and repeat the formula for speed: speed = distance/time. They need to understand the relationship between the three variables. Students should speak the formula as a sentence: speed is the distance traveled in a specific amount of time. This means that if two objects travel the same distance, the object that took a shorter amount of time will have the greater speed. This also means that an object with a greater speed will travel a longer distance in the same amount of time than an object with a lower speed.

Once students have learned and understand the formulas for speed/velocity, acceleration, force, momentum, power, work, kinetic energy, mechanical energy, and pressure (and have learned the process of KQS), students will work with their lab partners to complete a scavenger hunt activity with 27 sports-related word problems (3 for each formula).

Each word problem will be printed on colored cardstock and will have a corresponding letter at the top and an answer to a different problem on the bottom. The questions are posted on the walls around the classroom. Since we don't want students all starting at the same problem, students will be able to pick any question and start there. Once the students have solved the problem for A for example, they will look around the room for the card that will have the answer to A, and then complete that word problem, and so on, showing their work (KQS) along with the appropriate letter. What they will end up with is a chain of letters that is in a specific order. Students must show all work using the KQS strategy to get credit for the assignment, and they must work in tandem with their lab partner.

This activity provides an opportunity for students to check their work without really knowing the answer, because if they can't find their answer on one of the other papers around the room, they know their answer is wrong. This along with working with a partner also allows students the ability to drive this activity through cooperative learning, while allowing the teacher to work one-on-one with learners who are struggling with the material.

Activity #3: Culminating Project- From Pro to Gold

Project-based learning is such an important way for students to learn. It teaches them how to become organized, it teaches them to budget their time effectively, and gives them the opportunity to bridge real-world experiences with their education. Most interestingly, it makes students "feel more responsible for finishing assignments and understand the relationship between their success in school and success in the real world."[7]

For the culminating activity for this unit, I have designed a project that I'm calling "From Pro to Gold". Students will each be given access to a computer and will spend a few days in class gathering research. Students will choose an athlete from the NFL or NBA (they are welcome to choose another sport and I will work with them individually to design specific statistical standards) and they will be tasked with comparing their chosen athlete against top 8-10 winners from the 2012 London Olympics. Students will evaluate their athlete by comparing him/her to a selection of elite Olympic athletes and their statistics from three Olympic events: the 100-meter dash, the long jump, and the high jump. The student will use statistics from the NFL or NBA combine (or other approved sport/source) to gather comparable data and convert their data to equivalent units of measure. Students will collect their data via reliable websites, not necessarily limited to the ones I have provided (listed in the student instructions).

Once all data is collected, students will be responsible for scientifically communicating this information. Students will be expected to create graphs, charts, and tables that express this information in a meaningful way, and they should be able to compare their athlete with the top 2012 London Olympic competitors.

The final component to the project is a presentation component where students will communicate their findings in a creative way using a variety of presentation mediums. These visual representations will be assembled as a final product, which will have a differentiated list from which to choose. Students can create a professional poster or infographic, PowerPoint presentation, media presentation, or a video, including but not limited to a trailer-type video, a music video, an ESPN-style interview with their athlete, or even a mock Sport Science video.

Students will receive a copy of the instructions below:

Mrs. Coggins
The Physics of Sports: From Pro to Gold
Due Date:

Professional athletes have very specific skill sets. Even within the same sport, each position requires a specific set of strengths and skills. But have you ever wondered how your favorite athlete would do if they were to compete in the Olympics? Olympic athletes are said to be some of the best athletes in the world. They train and condition their bodies their whole lives to be in top physical shape for a very small window of time. Professional athletes are no different. Or are they?

Your job is to choose one football or basketball player and predict how they would place in Olympic events. Start by choosing either a football player or a basketball player who has been drafted into the NFL or NBA in the past few years. (Or you can choose one of the legends of your sport, or even choose another sport, but it may be difficult to find this information!)

You will use London 2012 Olympic statistics as your reference, using the website www.olympics.org/sports. You will focus on the 100 m dash, the long jump, and the high jump.

If you choose an NFL player:
You will use www.nfl.com/combine to research your player's statistics. The statistics you should focus on are the 40-yard dash, the vertical jump, and the broad jump.

- Your athlete's 40-yard dash will compare with the top ten finishers in the London 2012 Olympic 100 m dash. You will need to convert yards to meters, or vice versa.
    - Once you have converted your units of measure, you are ready to compare your data. How did your athlete do? Did he place in the top ten?

    - Now, let's see who has a faster speed. Using the formula for speed (Remember, Speed = distance/time) and the given distances and times, list and then chart all 11 athlete's speeds (the 10 Olympic athletes and your chosen athlete). Is speed an important skill for your athlete to have in his current position? How does your athlete rank in terms of speed with some of the fastest athletes in the world?
- The vertical jump will compare with the top ten finishers in the London 2012 Olympic high jump, which is measured in meters. Again, you will need to convert your units of measure!
    - Once you have converted your units of measure, you are ready to compare your data. How did your athlete do? Did he place in the top ten?
    - So we know who jumped higher. But how does that relate to physics? Work = force x distance, right? And force is measured in Newtons. Take the athlete's weight (you may have to research this from somewhere other than the Olympic website) and use the online unit conversion site below to find the athlete's weight from pounds to Newtons. Once you know the Newtons and the distance of the long jump, you can measure the work!
    - So who did more work? Was it the person who jumped higher? Was it the person who weighed more? What does that mean? How does that relate to your athlete? Chart your results.
- The broad jump will compare with the Olympic long jump, which also measured in meters. Again, you will need to convert your units of measure!
    - Once you have converted your units of measure, you are ready to compare your data. How did your athlete do? Did he place in the top ten?
    - So we know who jumped farther. But how does that relate to physics? Work = force x distance, right? And force is measured in Newtons. Take the athlete's weight (you may have to research this from somewhere other than the Olympic website) and use the online unit conversion site below to find the athlete's weight from pounds to Newtons. Once you know the Newtons and the distance of the long jump, you can measure the work!
    - So who did more work? Was it the person who jumped farther? Was it the person who weighed more? What does that mean? How does that relate to your athlete? Is weight more of a factor here or with the high jump? Chart your results.
- Now, here is the **most important part**. How relevant are these three measures to your athlete? By that I mean is the 40-yard dash a fair measure against the 100-meter dash? Why or why not? What about the long jump compared to the broad jump, and the vertical jump compared to the high jump?
    - If you argue that these are not appropriate statistics to measure against one another, explain why. Is there an alternate measure you could use?
    - When you are making your arguments, be sure to include relevant physics terms like momentum and acceleration.

If you choose an NBA player:

You will use http://www.nba.com/2013/news/05/17/nba-draft-combine-results/ to research your player's statistics. You are welcome to search previous years' results on the NBA website. You should focus on the statistics of three-quarter time and standard leap.

- Three-quarter time refers to how long it takes an athlete to run ¾ of the length of the court, which is 64 feet. You will compare this statistic to the Olympic 100 m dash (don't forget to convert feet to meters or vice versa).
    - Once you have converted your units of measure, you are ready to compare your data. How did your athlete do? Did he place in the top ten?
    - Now, let's see who has a faster speed. Using the formula for speed (Speed = distance/time) and the given distances and times, list and then chart all 11 athlete's speeds (the 10 Olympic athletes and your chosen athlete). Is speed an important skill for your athlete to have? How does your athlete rank in terms of speed with some of the fastest athletes in the world?
- The standard leap will compare with the Olympic high jump, which is measured in meters. Again, you will need to convert your units of measure!
    - Once you have converted your units of measure, you are ready to compare your data. How did your athlete do? Did he place in the top ten?
    - So we know who jumped higher. But how does that relate to physics? Work = force x distance, right? And force is measured in Newtons. Take the athlete's weight (you may have to research this from somewhere other than the Olympic website) and use the online unit conversion site below to find the athlete's weight from pounds to Newtons. Once you know the Newtons and the distance of the long jump, you can measure the work!
    - So who did more work? Was it the person who jumped higher? Was it the person who weighed more? What does that mean? How does that relate to your athlete? Chart your results.
- Now, here is the **most important part**. How relevant are these three measures to your athlete? By that I mean is the three-quarter time a fair measure against the 100-meter dash? Why or why not? What about the standard leap compared to the high jump?
    - If you argue that these are not appropriate statistics to measure against one another, explain why. Is there an alternate measure you could use?
    - When you are making your arguments, be sure to include relevant physics terms like momentum and acceleration.

- Once you have recorded and charted your data, it is up to you how you would like to present it. You can write a report, or you can create a PowerPoint, video, or poster. If you create a video, you can present that any way you would like. You have the option of creating a trailer on iMovie, or making a music video, or even "interviewing" your athlete and Olympic athletes.

- You must include graphics, charts, and images, including logos and athlete photos.
- The more evident it is you put a lot of effort into this project, the more points you will be awarded.
- Yes, there is a lot of work here, but have fun with it! If you want to do a different sport and you can find all the key components I've listed, go for it! If you want to compare to female Olympic athletes, you can do that as well! Show me what you've learned and make this something people will stop to look at and learn from as well!

Some additional helpful sites:
http://www.unit-conversion.info (Weight and Mass Unit Conversion, Length Unit Conversion)
www.topendsports.com
www.bleacherreport.com
www.draftexpress.com
And of course you're welcome to use whatever other sites you would like, as long as they are reliable and credible sites! ☺

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*It is important to note that technological literacy is a key component of this unit. Prior to the completion of this activity, students will have been given a mini-lesson on Google Drive and its capabilities for uploading, creating, and storing presentations, documents, and videos. Students will be expected to use Google Drive as their sole instrument of communication with me for turning in assignments and receiving feedback. This also streamlines the communication process, eliminating clogged inboxes, dozens of flash drives, and files that never seem to convert properly from home to school.

It should also be noted that while a large amount of time to complete this culminating activity will be given in class, students are also expected to work on this project outside of school. Time will need to be given for students to present their projects to the class at the end of the unit.

An extension activity for higher-level students or an alternate assignment could be to have the students select a sport and build their "fantasy team" based on physics-based statistics like speed, power, and momentum. For example, if a student chooses to create a "fantasy" football team, who would you choose as your running back? Why? What physics-based characteristics make this athlete an elite enough candidate to join your team? Once this fantasy team is assembled, students could even go as far as to chart their progress throughout the season and see how they fare against other students' teams, sparking competition. This could even be a class versus class assignment, where progress is charted for all classes to see.

Appendix: Implementing NC Essential Standards and Common Core Standards

The following Essential Standards for North Carolina 7th Grade Science will be emphasized during this unit:

- 7.P.1 Understand motion, the effects of forces on motion and the graphical representations of motion.
- 7.P.2 Understand forms of energy, energy transfer and transformation and conservation of mechanical systems.

The Common Core State Standards for Mathematics dictate that our students should be able to solve real-life and mathematical problems using numerical and algebraic expressions and equations. In addition, the following overarching standards for Mathematical Practices will be emphasized during this unit:

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them.
- CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others.
- CCSS.Math.Practice.MP4 Model with mathematics.
- CCSS.Math.Practice.MP5 Use appropriate tools strategically.
- CCSS.Math.Practice.MP6 Attend to precision.
- CCSS.Math.Practice.MP7 Look for and make use of structure.

The Common Core State Standards for Literacy dictate that our students should be able to:

- CCSS.ELA-Literacy.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
- CCSS.ELA-Literacy.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- CCSS.ELA-Literacy.W.7.1 Write arguments to support claims with clear reasons and relevant evidence.

Appendix A: Activity #1 Speed Racer Lab Sheet

Speed Racer Lab Sheet Name ________________________

Time Trials- Record your data below:

	Trial 1 Time	Trial 2 Time	Trial 3 Time	Average Time	Average Speed
10 m					
15 m					
20 m					

Distance-Time Graph- Chart your above data as a line graph below:
(Be sure to label your x axis and y axis & give your graph a title)

Now that your data collection is complete, analyze your data. Use the back of this sheet to record your answers once you have discussed with your group.

Explain the correlation between distance and time, and how it relates to speed.

What does a horizontal line on your graph mean? What about a steeply sloped line? A slightly sloped line?

Did the cars seem to maintain a consistent speed throughout the trials?

Is that a factor? Why would that matter?

Appendix B:

Having a Ball Jigsaw Graphic Organizer   Name ________

BASEBALL Origins of this ball? Reasons for its shape? Advantages to its shape? Disadvantages to its shape? Any other helpful info?	***SOCCER BALL*** Origins of this ball? Reasons for its shape? Advantages to its shape? Disadvantages to its shape? Any other helpful info?
FOOTBALL Origins of this ball? Reasons for its shape? Advantages to its shape? Disadvantages to its shape? Any other helpful info?	***GOLF BALL*** Origins of this ball? Reasons for its shape? Advantages to its shape? Disadvantages to its shape? Any other helpful info?

Notes

[1](Hutchison 2010) p. 150
[2](Tomlinson 2001) p. 11
[3](Tomlinson 2001) p. 13
[4](Chiappetta 2010) p. 123
[5](Barba 1998) p. 20
[6](Wormeli 2005) p. 104
[7](Tate 2010) p. 86

Annotated Bibliography for Teachers

Barba, Robertta H. *Science in the multicultural classroom: a guide to teaching and learning*. 2nd ed. Boston: Allyn and Bacon, 1998.
This book is useful for creating lessons complete with strategies involving manipulative materials and laboratory equipment.

Chiappetta, Eugene L., and Thomas R. Koballa. *Science instruction in the middle and secondary schools: developing fundamental knowledge and skills*. 7th ed. Boston, Mass.: Allyn & Bacon, 2010.
This book is useful for developing science lessons using inquiry-based learning.

Common Core State Standards Initiative. http://www.corestandards.org/
I used this website to access the Common Core Standards for math and language arts, and the Essential Standards for science.

Hutchison, Charles B. *Teaching Diverse Learners: With Basic Principles, Classroom Insights, and Best Practices.* Charlotte, NC: Catawba Publishing Company, 2010.
This book is helpful in exploring strategies for creating differentiation in a classroom with diverse learners.

Lemov, Doug. *Teach like a champion: 49 techniques that put students on the path to college*. San Francisco: Jossey-Bass, 2010.
This book is useful for exploring different techniques for improving literacy decoding, fluency, vocabulary, and comprehension.

Sciencesaurus: a student handbook. Wilmington, MA: Great Source Education Group, 2002.
This text is a great source for easy to understand science concepts. This book is helpful as a teacher or student reference.

Tate, Marcia L.. *Worksheets don't grow dendrites: 20 instructional strategies that engage the brain*. 2nd ed. Thousand Oaks, Calif.: Corwin Press, 2010.
This book is a wealth of information for how to teach a classroom full of engaged learners using a variety of instructional strategies, mainly involving movement and project-based learning.

Tomlinson, Carol A. *How to differentiate instruction in mixed-ability classrooms*. 2nd ed. Alexandria, Va.: Association for Supervision and Curriculum Development, 2001.
This book is very useful in finding ideas for differentiation in heterogeneous classrooms with advanced and struggling learners.

Wormeli, Rick. *Summarization in any subject: 50 techniques to improve student learning*. Alexandria, VA: Association for Supervision and Curriculum Development, 2005.
This book is useful for implementing summarization strategies into lessons, including the jigsaw strategy used in activity #2.

Reading List for Students (Included within each activity, recapped below)

http://espn.go.com/espn/sportscience/
http://science360.gov/files/
http://curiosity.discovery.com/question/how-many-stitches-on-baseball
http://www.soccerballworld.com/History.htm
http://www.nbclearn.com/nfl
http://www.scientificamerican.com/article.cfm?id=how-do-dimples-in-golf-ba
www.olympics.org/sports
www.nfl.com/combine
http://www.nba.com/2013/news/05/17/nba-draft-combine-results/
http://www.unit-conversion.info
www.topendsports.com
www.bleacherreport.com
www.draftexpress.com

List of Materials for Classroom Use

Calculator
Graph paper
Meter sticks
Remote-controlled car
Stopwatch
Lab Worksheet for Activity #1
Basketball
Baseball/bat
Golf ball/club

Football
Soccer ball/goal
Graphic Organizer for Activity #2
27 word problems on colored cardstock for Activity #3
Instructions for Culminating Activity #4
Guided notes, and interactive PowerPoint presentations
Interactive Student Notebooks
Laptop/computer/iPad/BYOT technology